Use of AIRS data at the Met Office

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AIRS Science Team Meeting – 28 March 2007

Outline

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- Use of high-peaking AIRS channels over land (operational)
- Assimilation of cloud affected radiances (forecast trials imminent)
- Update on total column ozone (one forecast trial complete)
- Validation of AATSR sea surface temperatures (complete)

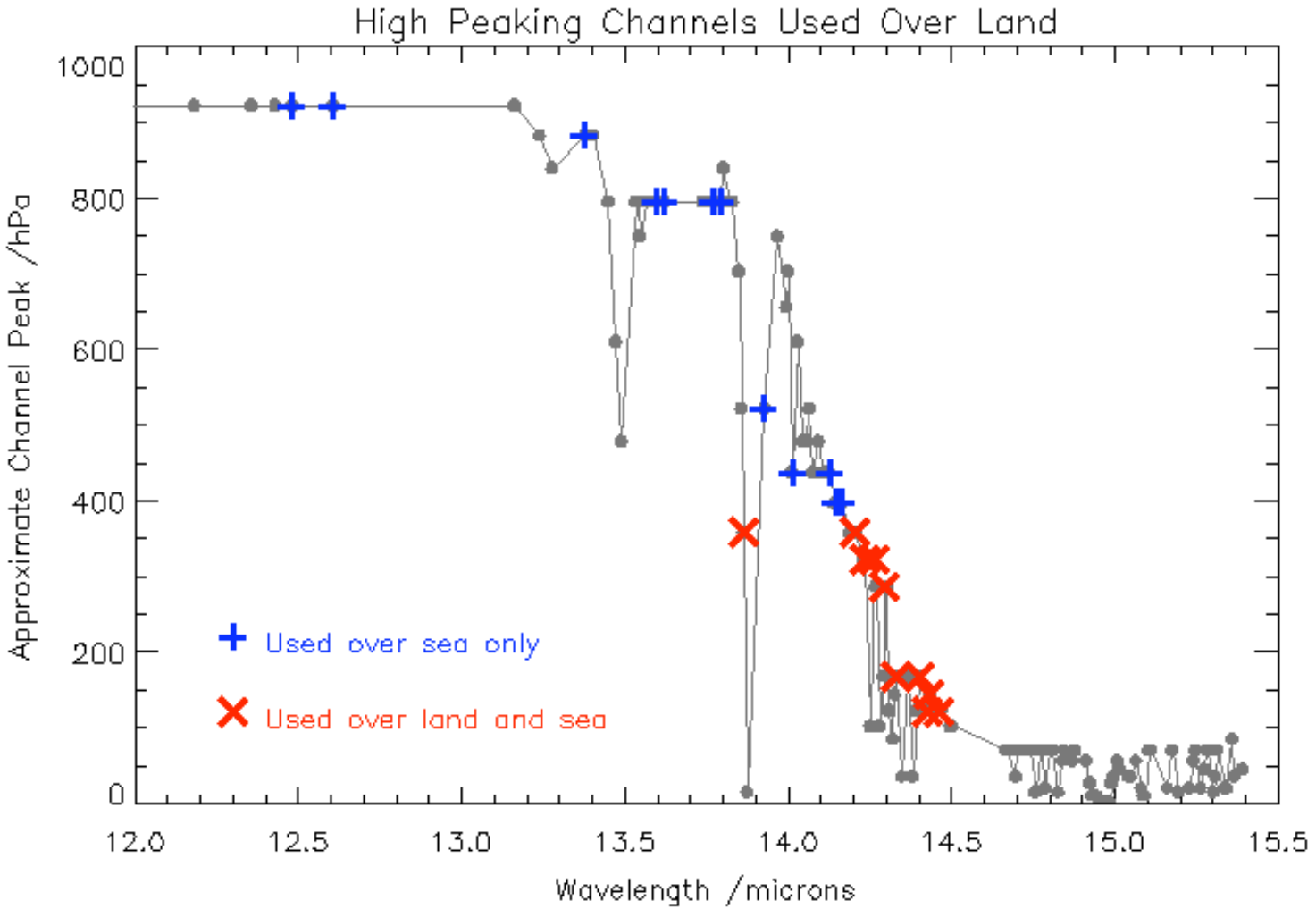
Use of High-Peaking AIRS Channels Over Land

Sreerekha Thonipparambil

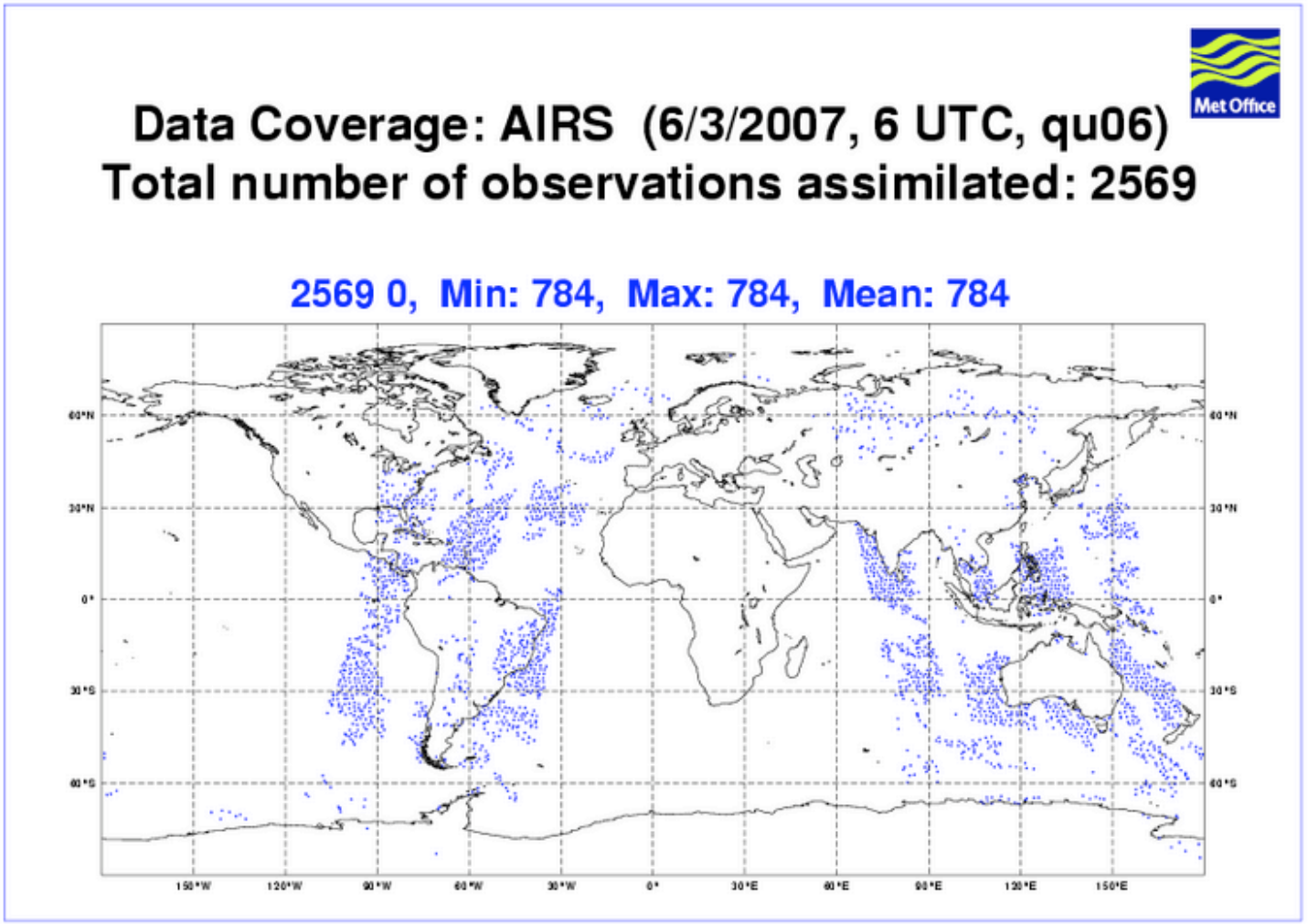
High Peaking Channels over Land

- 10 channels that peak over 400hPa were enabled for observations over land.
- Cloud detection is the same as that used over sea, except that AMSU-A Channel 3 is not used.
- Forecast trials showed neutral impact on the NWP index.
- Some mild improvements seen in the fit to some AMSU-A channels.

High Peaking Channels



Data Coverage



Assimilation of Cloud Affected Radiances

Ed Pavelin

Motivation

- Currently: AIRS data only used in cloud-free regions
- Large proportion of AIRS data discarded due to cloud
- Forecast is likely to be sensitive to cloudy regions
- We would like to use cloudy data from AIRS (and IASI)

Approaches to cloudy IR radiance assimilation

- The dream: Full cloudy 4D-Var
  - Requires full cloudy radiative transfer and cloud physics in 4DVar
  - Model doesn't resolve cloud on small enough scales
- Cloud clearing
  - Reconstruct clear-sky radiances assuming *T* and *q* locally homogeneous in horizontal
  - Analysis biased towards clear-sky characteristics (drier)
- Reject cloud-affected channels (e.g. ECMWF)
  - Compare observations with cloud-free background
  - No information at or below cloud top

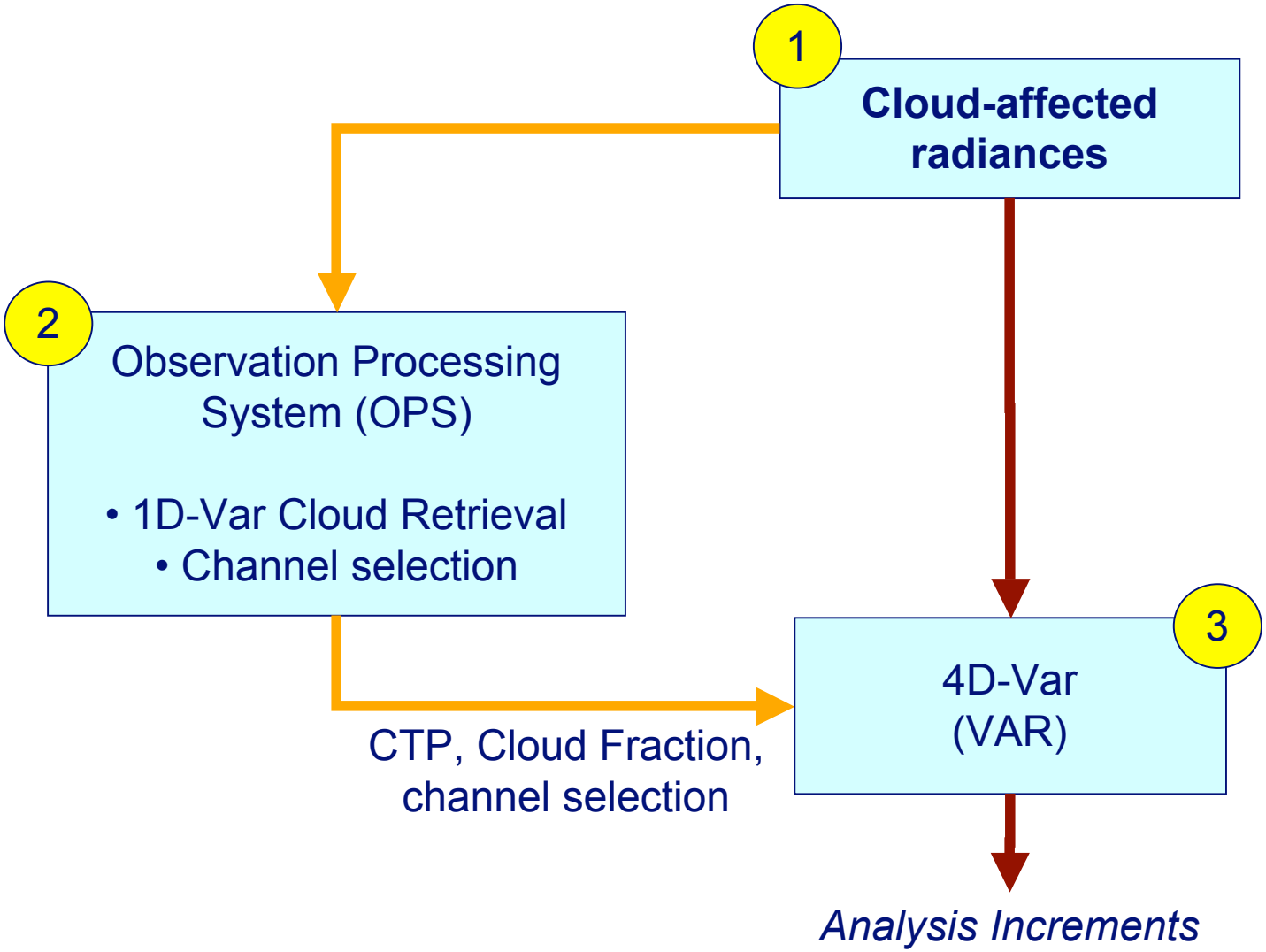
A new technique…

- Retrieve cloud parameters in 1D-Var
  - Using RTTOV: Single level “grey” cloud
  - Cloud first guess from minimum residual method (9 channels)
  - Retrieve:
    - cloud top pressure
    - effective cloud fraction (=$N\varepsilon$) for each FOV
- Pass cloudy radiances, retrieved CTP and CF to 4D-Var
- Use cloud parameters as fixed constraints on 4D-Var radiative transfer

Bias problems…

- In many cases, 1D-Var cloud model is unrealistic
  - Not (generally) single-level grey cloud
  - Cloud is generally multi-level, 3D
  - Leads to biases below cloud top
- **Solution: Remove channels most likely to be poorly modelled**
- Simple automatic channel selection:
  - Reject all channels peaking below retrieved cloud top
  - 10% of weighting function area allowed below cloud top
  - Channel selection carried out for each sounding

Simplified processing flowchart



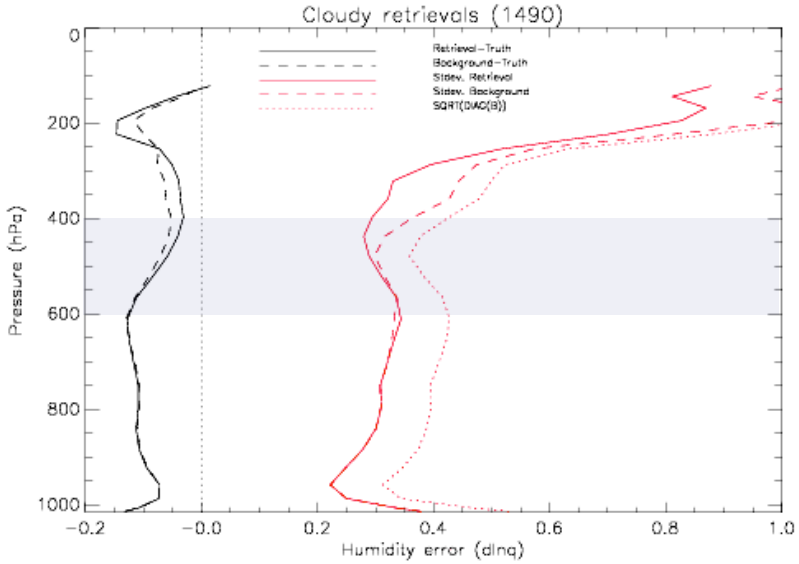
Simulation study framework

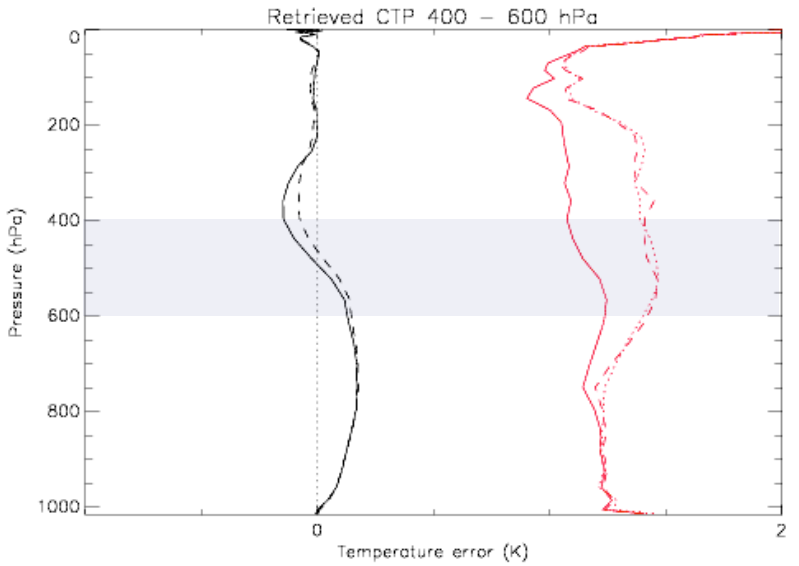
- Use ECMWF 60-level sampled profile dataset (Chevallier, 2001)
  - **13495 profiles** of T, q, O3, cloud liquid water, cloud ice water and surface variables
  - Use only sea profiles (**5810**)
- Simulate cloudy AIRS BTs using a cloudy radiative transfer model (RTTOV_CLD)
  - Add simulated measurement errors
- Simulate model background profiles
  - Add errors to model profiles consistent with Met Office B-Matrix
- Perform experiments using stand-alone 1D-Var code:
  1. Retrieve cloud parameters in 1D-Var
  2. Simulate assimilation of cloudy radiances with fixed cloud parameters: Use 1D-Var instead of 4D-Var

Mid-level cloud with channel selection

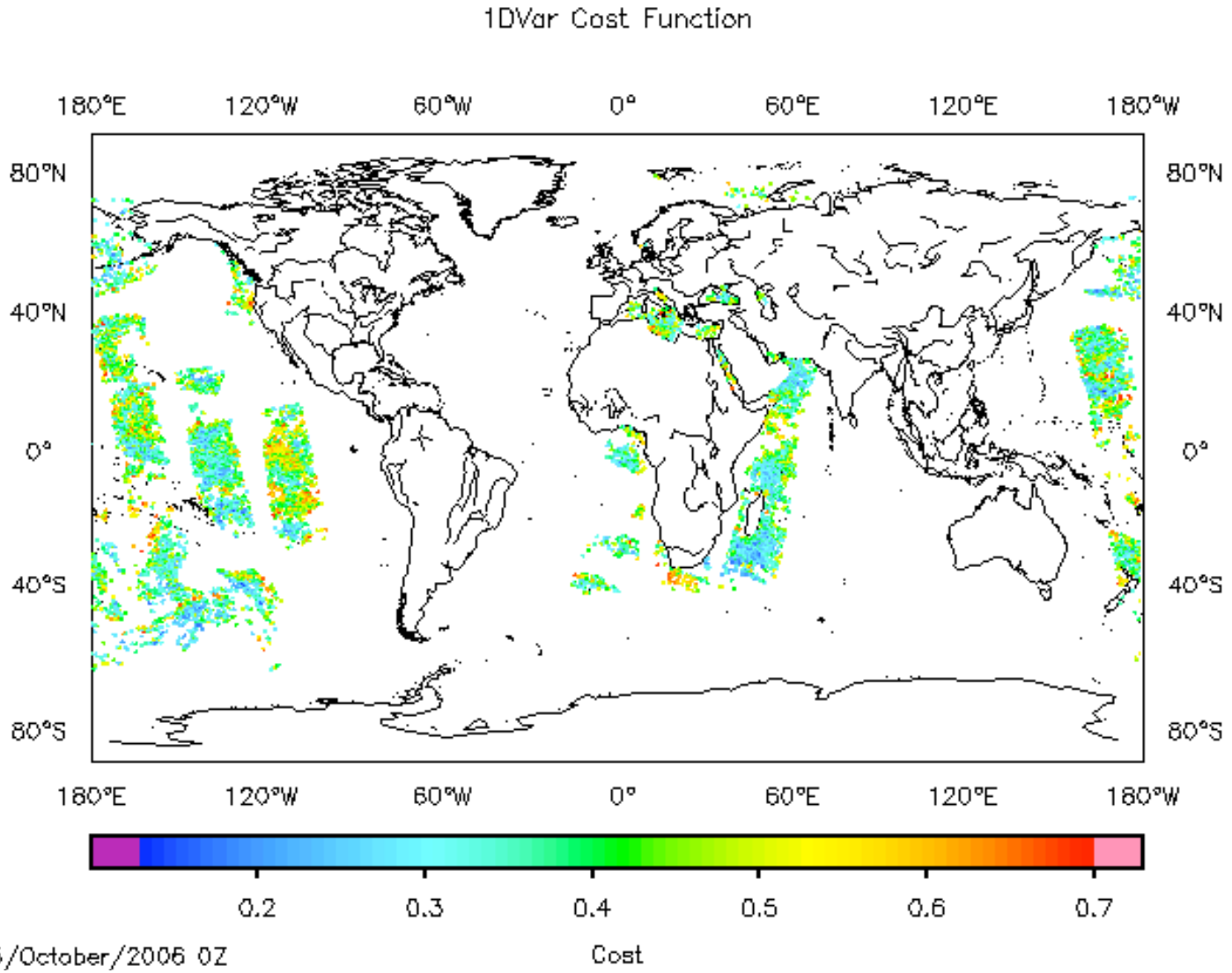
"Mid-level" cases: CTP 400-600 hPa

- 28% of cases
- Analysis improved above cloud
- Significant temperature information below cloud (from semi-transparent cloud + vertical correlations)
- Humidity analysis well-behaved below cloud (follows background)
- Bias much reduced compared with "all channels" case (follows background)

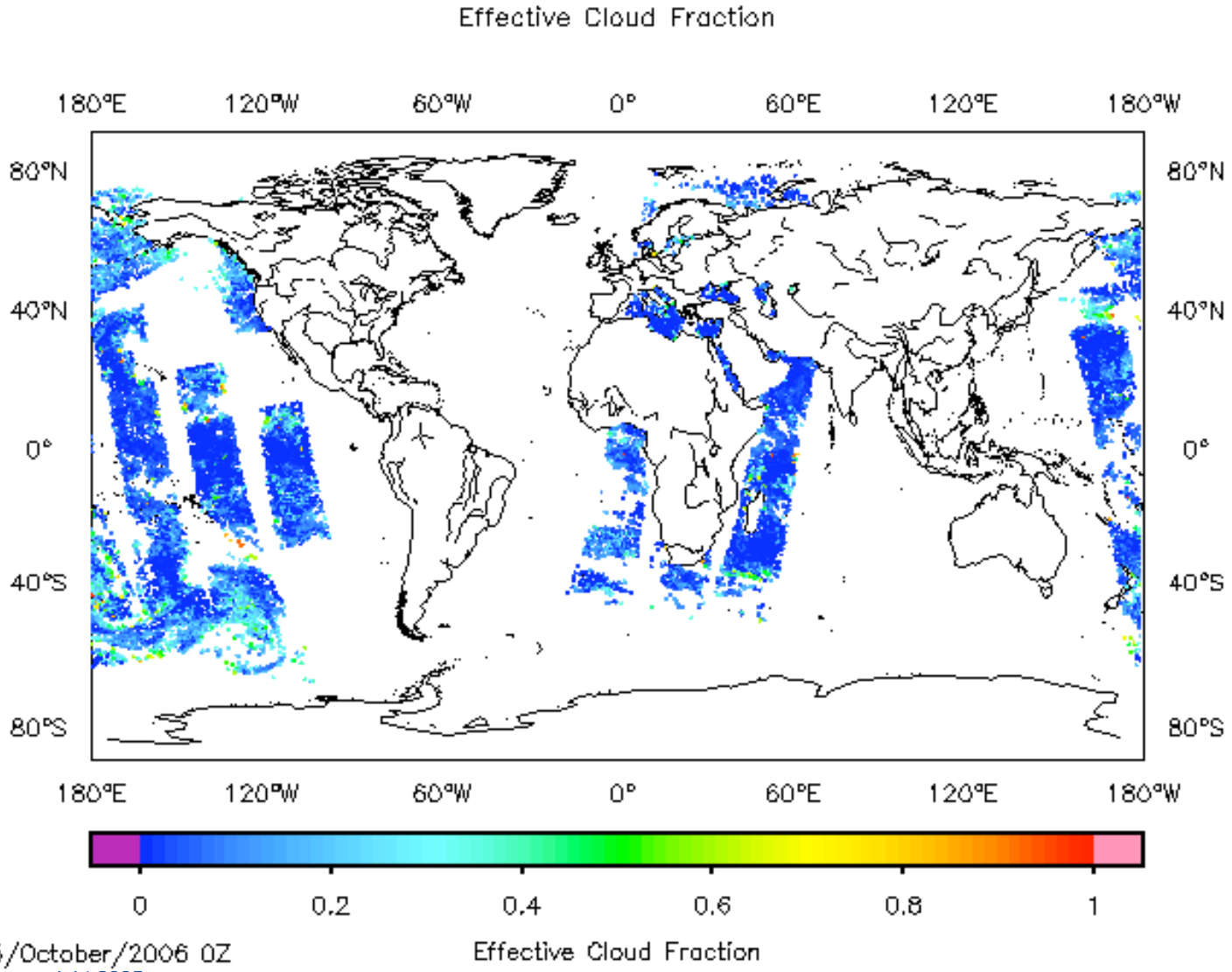




Coverage: Clear AIRS



Coverage: Cloudy AIRS



Status

- Approx. 65% increase in AIRS obs passed to VAR
- Approx. 2.5x increase in total AIRS 1DVar processing time
- Cost neutral in VAR – no extra iterations
- Final tuning being carried out
- Forecast trials imminent

Total Column Ozone

James Cameron

Total Column Ozone

- Total column ozone (TCO) currently set by monthly coefficients and the temperature at 70hPa.
- Leads to difference of 1-2K between observed and simulated radiances in the ozone band.
- Previously suspected that ozone errors may lead to inaccurately retrieved water vapour.

Total Column Ozone

- Selected two channels (1082 and 1120) from 9.5 μm ozone band with representative Jacobians.
- Fit total column ozone in 1DVar.
- Use as fixed parameter in 4DVar.

- Forecast trials fitting total column ozone for Dec05/Jan06.
- Neutral impact.
- Increased cost when processing cloud-free fields of view only.

Validation of AATSR Sea Surface Temperature

Thomas Blackmore, Anne O'Carroll,
Roger Saunders, George Aumann

Validation of AATSR SST

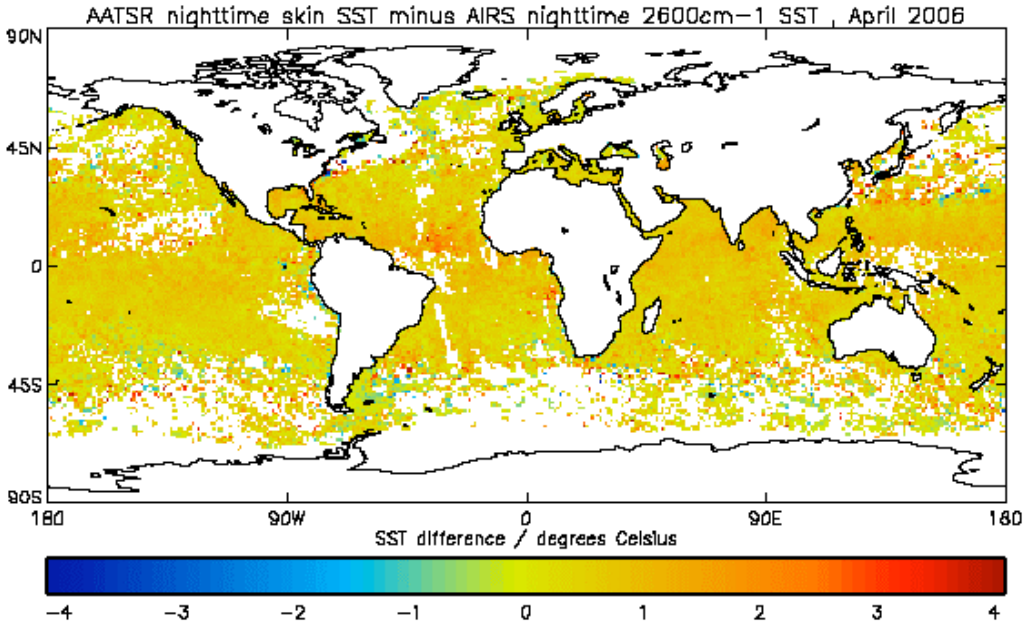
- Advanced Along-Track Scanning Radiometer on ESA's ENVISAT.
- Three infrared channels at 3.7, 11 and 12 μm.
- Inclined conical scanner with nadir and forward (~55°) views.
- Used to generate a SST product for climate research with an accuracy of 0.3K, long term stability of 0.1K and 10 arc minute resolution.

Comparison of AATSR and AIRS SST's

- Studied three months in 2006: Jan, April, June.
- Field comparison between:
  - Two different mean monthly night-time SST fields inferred from AIRS channels at 1231cm^{-1} and 2616cm^{-1}.
  - Dual-view, three-channel, night-time AATSR SST
- A three-way statistical comparison using AIRS, AATSR and Buoy SST's was carried out, allowing the error on each observation type to be derived.

Findings of AATSR SST minus AIRS SST

- AIRS gives consistently colder SST's than AATSR by about 0.6K probably due to residual cloud contamination of the AIRS data.
- The AIRS 2616cm^{-1} channel provides a more accurate SST than the AIRS 1231cm^{-1} SST attributed to a lower water vapour continuum absorption at 2616cm^{-1}.



Findings of the Three-way comparison

- Using AIRS 2616cm^{-1} SST, AATSR SST has the smallest error of 0.14K, buoys have 0.22K and AIRS has the largest error of 0.41K
- Suggests that AIRS gives a cooler SST than AATSR by about 0.6K.

- AIRS SST are simple single channel retrievals whereas AATSR uses multiple channels optimised for different atmospheres.
- AIRS suffers more residual cloud contamination with its 15km FOV compared to AATSR's 1km FOV.

Conclusions

Summary

- Using 10 high-peaking AIRS channels over land since 6 March.
- Assimilation of cloudy fields of view close to forecast trials.
- Fitting total column ozone has shown little effect.
- AIRS has being used to validate an AATSR sea surface temperature product.

Questions

AATSR references

Unfortunately no references are available for this at present.

Tom Blackmore's Technical Report 499, will appear on this web site in due course:
http://www.metoffice.gov.uk/research/nwp/publications/papers/technical_reports/index.html

More detail on the 3-way error analysis technique will appear in this paper:

O'Carroll AG, Eyre JR and Saunders RW, 2006a, Three-point error analysis between AATSR, AMSR-E and in situ sea surface temperature observations, Submitted to J. Atmos. Oceanic Technol., 1st Nov 2006